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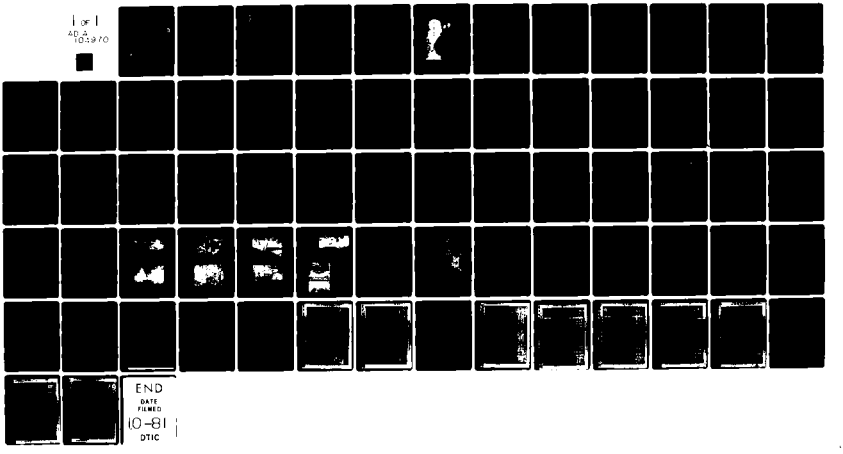

LEVEL II

MISSISSIPPI – KASKASKIA – ST. LOUIS BASIN

CEDAR HILL LAKE NO. I DAM

JEFFERSON COUNTY, MISSOURI

MO 30073

PHASE I INSPECTION REPORT NATIONAL DAM SAFETY PROGRAM

PREPARED BY: U. S. ARMY ENGINEER DISTRICT, ST. LOUIS

FOR: STATE OF MISSOURI

JANUARY 1979

UNCLASSIFIED

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Dam Safety, Lake, Dam Inspection, Private Dams

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

This report was prepared under the National Program of Inspection of Non-Federal Dams. This report assesses the general condition of the dam with respect to safety, based on available data and on visual inspection, to determine if the dam poses hazards to human life or property.

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DEPARTMENT OF THE ARMY
ST. LOUIS DISTRICT, CORPS OF ENGINEERS
210 NORTH 12TH STREET
ST. LOUIS, MISSOURI 63101

IN REPLY REFER TO

SUBJECT: Cedar Hill Lake No. 1 Dam (Mo. 30073),
Phase I Inspection Report

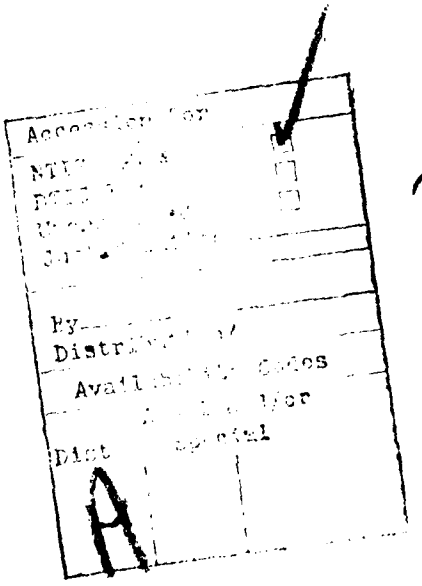
This report presents the results of field inspection and evaluation of Cedar Hill Lake No. 1 Dam (Mo. 30073). It was prepared under the National Program of Inspection of Non-Federal Dams.

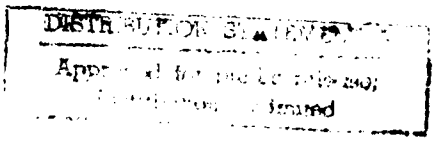
SUBMITTED BY: SIGNED
Chief, Engineering Division

1 MAR 19[illegible]
(Date)

APPROVED BY: SIGNED
Colonel, CE, District Engineer

1 MAR 1979
(Date)





PHASE I INSPECTION REPORT
NATIONAL DAM SAFETY PROGRAM

Name of Dam:	Cedar Hill Lake No. 1 Dam, Missouri Inv. No. 30073
State Located:	Missouri
County Located:	Jefferson
Stream:	Unnamed Tributary of Big River
Date of Inspection:	October 2, 1978

Assessment of General Condition

Cedar Hill Lake No. 1 Dam No. Mo.30073 was inspected using the "Recommended Guidelines for Safety Inspection of Dams". These guidelines were developed by the Chief of Engineers, U.S. Army, Washington, D.C., with the help of Federal and state agencies, professional engineering organizations, and private engineers. The resulting guidelines are considered to represent a consensus of the engineering profession.

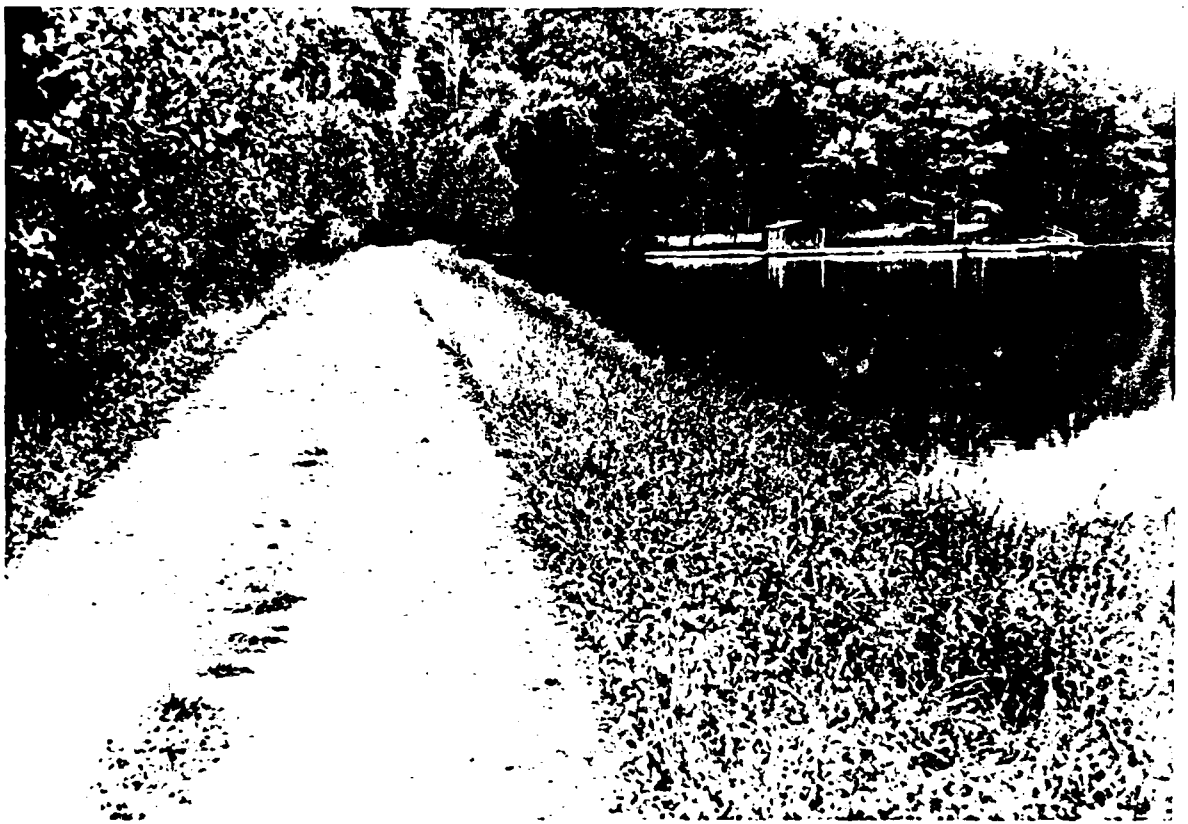
Based on the criteria in the guidelines, the dam is in the high hazard potential classification, which means that loss of life and appreciable property loss could occur in the event of failure of the dam. Six houses, two improved road crossings, and one State Highway crossing would be subjected to flooding, with possible damage and/or destruction, and possible loss of life. Cedar Hill Lake No. 1 Dam is in the small size classification since it is less than 40 feet high and impounds less than 1,000 acre-feet of water.

Our inspection and evaluation indicates that the spillway of Cedar Hill Lake No. 1 Dam does not meet the criteria set forth in the guidelines for a dam having the above size and hazard potential. Cedar Hill Lake No. 1 Dam is a small size dam with a high hazard potential required by the guidelines to pass from one-half Probable Maximum Flood to the Probable Maximum Flood without overtopping. Since there is significant development downstream of the dam, the Probable Maximum Flood is the appropriate Spillway Design Flood (SDF). It was determined that the spillway will pass 28 percent of the Probable Maximum Flood without overtopping of the dam. Our evaluation indicates that the spillway will pass the 100-year flood; that is, a flood having a 1 percent chance of being equalled or exceeded during any given year.

The Probable Maximum Flood is defined as the flood discharge that may be expected from the most severe combination of critical meteorological and hydrologic conditions that are reasonably possible in the region.

Other deficiencies noted by the inspection team were a need for a periodic inspection by a engineer experienced in the design and construction of dams; lack of a maintenance schedule; trees and large brush on the downstream embankment slope; and vegetative growth in the spillway channel. The lack of stability and seepage analyses on record is also a deficiency that should be corrected. These analyses should concentrate on the area exhibiting seepage on the downstream embankment slope.

It is recommended that the owner take action to correct or control the deficiencies described above.



CEDAR HILL LAKE NO. 1 DAM

PHASE I INSPECTION REPORT
NATIONAL DAM SAFETY PROGRAM

Cedar Hill Lake No. 1 Dam, I.D. No. 30073

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NATIONAL DAM SAFETY PROGRAM

CEDAR HILL LAKE NO. 1 DAM, Missouri Inv. No. 30073

SECTION 1: PROJECT INFORMATION

1.1 General

a. Authority

The Dam Inspection Act, Public Law 92-367 of August, 1972, authorizes the Secretary of the Army, through the Corps of Engineers, to initiate a national program of dam inspections. Inspection for the Cedar Hill Lake No. 1 Dam was carried out under Contract DACW 43-78-C-0160 to the Department of the Army, St. Louis District, Corps of Engineers, by the engineering firms of Consoer, Townsend & Associates Ltd., and Engineering Consultants, Inc. (A Joint Venture), of St. Louis, Missouri.

b. *Purpose of Inspection*

The visual inspection of the Cedar Hill Lake No. 1 Dam was made on October 2, 1978. The purpose of the inspection was to make a general assessment as to the structural integrity and operational adequacy of the dam embankment and its appurtenant structures.

c. Scope of Report

This report summarizes available pertinent data relating to the project; presents a summary of visual observations made during the field inspection; presents an evaluation of hydrologic and hydraulic conditions at the site; presents an evaluation as to the structural adequacy of the various project features; and assesses the general condition of the dam with respect to safety.

It should be noted that reference in this report to left or right abutments is as viewed looking downstream. Where left abutment or left side of the dam is used in this report, this also refers to west abutment or side, and right to the east abutment or side.

d. Evaluation Criteria

Criteria used to evaluate the dam were furnished by the Department of the Army, Office of the Chief of Engineers, in "Recommended Guidelines for Safety Inspection of Dams", Appendix D. These guidelines were developed with the help of several Federal agencies and many state agencies, professional engineering organizations, and private engineers.

1.2 Description of the Project

a. Description of Dam and Appurtenances

It should be noted that design drawings are not available for the dam or appurtenant structures. The following description is based exclusively on observations and measurements made during the visual inspection.

The dam embankment is likely a homogeneous earthfill structure. The crest of the embankment has a width of 14 feet and a length of approximately 620 feet. The crest elevation is set at 530.5 feet above MSL, and the maximum height of the embankment is 38.5 feet above the minimum streambed elevation along the centerline of the dam.

The embankment section is constructed with 1V to 2H upstream and downstream slopes. A 20-foot wide berm is located 25 to 30 vertical feet below the dam crest on the downstream slope. The berm has a typical height of 8 feet, and a side slope of 1V to 1.5H. Surface observation of the embankment material found the material to be sandy clay with traces of silt. The material would be classified as CL by the Unified Soil Classification System.

Bedrock at the site and within the vicinity is composed of Ordovician age silty and chert dolomite. A residual clay, a weathered product of the bedrock, commonly mantles the rolling hills. Alluvial deposits are encountered along the stream courses of the area.

The right abutment of the dam and the spillway are founded in hard dolomite, while the left abutment appears to be founded in residual clay or bedrock. Bedrock bedding planes exposed in the spillway have attitudes of N65°W, 2°SW. Design or construction drawings of the project are not available, but it is likely the embankment, through the channel section, has been placed on residual clays and/or alluvial deposits.

Data is not available to provide a description of the foundation preparation for the dam.

The spillway for the Cedar Hill Lake No. 1 Dam is an open channel depression in the east abutment just beyond the end of the dam embankment. The spillway was cut in rock, and the discharge channel contains a series of rock falls before entering the natural channel. Cross-section of the spillway crest is trapezoidal in shape, with bottom width of 30 feet, side slopes 1V to 5H on the left and 1V to 0.25H on the right. A 2-foot high wire fence was constructed as a trashrack across the crest section.

There is no operating outlet pipe or low level drain at the dam.

The reservoir at Cedar Hill Lake No. 1 Dam impounds about 200 acre-feet of water from a drainage area of 0.49 square miles.

b. Location

Cedar Hill Lake No. 1 Dam is located on an unnamed tributary of the Big River, Jefferson County, Missouri. The nearest downstream community is Cedar Hill, Missouri, approximately 1-1/2 miles from the dam. The main access from Cedar Hill, Missouri, is south on Highway 30 for one mile to Route B, then east on Route B for approximately 800 feet, and then south on Ficken Road. This road will lead directly to the Cedar Hill Lakes, which are on Grandview and Hilltop Roads. The dam and reservoir are shown on the Cedar Hill Quadrangle Sheet (7.5 minute series) in Section 35, Township 42 North, Range 3 East.

c. Size Classification

According to the "Recommended Guidelines for Safety Inspection of Dams", by the U.S. Department of the Army, Office of the Chief Engineer, the dam is classified in the dam size category as being "Small" since its storage is less than 1,000 acre-feet. The dam is also classified as "Small" in dam height category because its height is less than 40 feet. The overall size classification is, accordingly, "Small" in size.

d. Hazard Classification

The dam has been classified as having "High" hazard potential in the National Inventory of Dams, on the basis that in the event of failure of the dam or its appurtenances, excessive damage could occur to downstream property, together with the possibility of the loss of life. Our findings concur with the classification. The estimated damage zone extends three miles downstream of the dam. Within the damage zone are six houses, two improved road crossings, and State Highway 30 crossing.

e. Ownership

Cedar Hill Lake No. 1 Dam is owned by Property Owners Corporation, a group of home owners who live around the perimeter of the Cedar Hill Lakes. The mailing address is Property Owners Corporation, c/o Duke Beckerman, P.O. Box 34A, Route 2, Cedar Hill, Missouri 63016.

f. Purpose of Dam

The purpose of the dam is to impound water for recreational use as a private lake.

g. Design and Construction History

Cedar Hill Lake No. 1 Dam was originally designed and constructed in 1949 by Walter Ficken, a private developer. No design plans or specifications were used at the time of construction.

h. Normal Operational Procedures

The dam is used to impound water for recreational purposes. There are no facilities present at the damsite which require any operation or maintenance. Water levels are controlled by rainfall, runoff, evaporation, and an uncontrolled spillway. Water level and maintenance records are not kept for Cedar Hill Lake No. 1 Dam.

1.3 Pertinent Data

a. Drainage Area (acres): 314

b. Discharge at Damsite

Estimated experienced maximum flood (cfs):	200
Estimated ungated spillway capacity at maximum pool elevation (cfs):	930

c. Elevation (Feet above MSL)

Top of dam:	530.5
Spillway crest:	527.0
Minimum streambed elevation at centerline of dam:	492.0
Maximum tailwater:	Unknown

d. Reservoir

Length of maximum pool (feet):	2,360

e. Storage (Acre-Feet)

Top of dam:	208

f. Reservoir Surface (Acres)

Top of dam:	16
Spillway crest:	13

g. Dam

Type:	Rolled Earthfill
Length:	620 feet
Height (maximum):	38.5 feet
Top width:	14 feet
Side slopes:	
Downstream	1V to 2H for top 25 to 30 vertical feet to a 20 foot wide berm, and 1V to 1.5H to ground surface
Upstream	1V to 2H

Zoning:	Unknown
Impervious core:	Unkwown
Cutoff:	Unknown
Grout curtain:	Unknown

h. Diversion and Regulating Tunnel — None

i. Spillway

Type:	Uncontrolled
Length of weir:	30 feet
Crest Elevation:	527 feet (MSL)

j. Regulating Outlets — None

SECTION 2: ENGINEERING DATA

2.1 Design

Design drawings are not available for the dam or appurtenant structures. The dam was designed and constructed in 1949 by Walter Ficken, a private developer. No drawings were made for the dam or appurtenant structures.

2.2 Construction

No construction data is available for the dam and appurtenant structures.

2.3 Operation

No operation data is available for Cedar Hill Lake No. 1 Dam.

2.4 Evaluation

a. Availability

No design drawings, design computations, construction data or operation data is available.

In addition, no pertinent data was available for review of hydrology, spillway capacity, flood routing through the reservoir, outlet capacity, slope stability, seepage analysis, or foundation conditions.

b. Adequacy

The available engineering data is inadequate to aid in evaluating the hydraulic and hydrologic capabilities and stability of the dam for Phase I investigations.

The lack of engineering data did not allow for a definitive review and evaluation. Therefore, the adequacy of this dam could not be assessed from the standpoint of reviewing and evaluating design, operation and construction data, but is based primarily on visual inspection, past performance history, and sound engineering judgment.

Seepage and stability analyses comparable to the requirements of the "Recommended Guidelines for Safety Inspection of Dams" were not available, which is considered a deficiency. These seepage and stability analyses should be performed for appropriate loading conditions (including earthquake loads) and made a matter of record.

c. Validity

No valid engineering data is available.

SECTION 3: VISUAL INSPECTION

3.1 Findings

a. General

A visual inspection of Cedar Hill Lake No. 1 Dam was made on October 2, 1978. The following persons were present during the inspection:

Name	Affiliation	Disciplines
Yin Au-Yeung	Engineering Consultants, Inc.	Project Engineer, Hydraulics and Hydrology
David Bramwell	Engineering Consultants, Inc.	Geology
Jon Diebel	Engineering Consultants, Inc.	Soils
John Ismert	Engineering Consultants, Inc.	Mechanical
Kevin Blume	Consoer, Townsend & Assoc., Ltd.	Civil & Structural

Specific observations are discussed below.

b. Dam

The crest of the dam is well protected by a gravel road base. Traffic on the crest is restricted to access to several private homes on the east side of the dam.

The upstream embankment slope does not have riprap for protection. As a result, some sloughing is occurring near the high water elevation. This has caused some steepening of the embankment slope, with the slope appearing to be as steep as 1V to 1H in some areas. Vegetation on the slope is not satisfactory for protection of the slope from erosion.

The downstream embankment slope is overgrown with trees and large brush. This heavy vegetation made proper inspection of the slope virtually impossible. Rodent activity was observed on the embankment slope.

A seepage area was observed on the downstream embankment slope approximately 200 feet west of the right abutment of the dam. The seep was found 2 to 5 vertical feet above a berm located 30 vertical feet down from the dam crest. The seep extends for a length of 75 feet, with a width of 10 feet, and is characterized by moist, boggy terrain, with phreatophytes. The fill in the area contained a larger number rocks than would normally be expected.

c. Appurtenant Structures

(1) Spillway

The spillway is a cut section in rock on the east side of the dam. The spillway approach channel, crest structure and discharge channel are well defined. A 2-foot high wire fence is constructed across the spillway crest as a trashrack. The uncontrolled spillway is the only structure existing at this dam to control pool levels. No water was observed to be flowing over the spillway crest at the time of inspection. There is heavy aquatic growth existing at the entrance to the spillway crest. One large tree is located on the left side of the approach channel and several smaller trees were noticed immediately downstream of the crest.

(2) Outlet Works

No outlet works or reservoir drain are provided for the damsite.

d. Reservoir Area

The water level was at elevation 525.05 feet above MSL at the time of the inspection.

There are thirteen private homes located near the reservoir shore. All of these homes have well kept lake-front properties. Behind these homes are woodlands and trees. No erosion, wave wash or slope slides were noticeable along the shore of the reservoir.

e. Downstream Channel

Spillway discharge through the crest structure will flow over a series of rock falls to reach the original channel. The rock falls function as excellent energy dissipators, and are in good condition.

3.2 Evaluation

The following items were observed which could affect the safety of the dam, or which will require maintenance within a reasonable period of time.

1. The seepage area observed on the downstream embankment slope.

2. The large brush and tree growth prevalent on the downstream embankment slope.

3. The sloughing and erosion of embankment materials on the upstream slope of the dam.

4. The rodent activity on the downstream embankment slope.

5. The vegetative growth in the spillway channel.

SECTION 4: OPERATIONAL PROCEDURES

4.1 Procedures

Cedar Hill Lake No. 1 is used solely for recreational purposes. There are no facilities or equipment at the damsite which require operation. The lake is kept as full as possible at all times, and there is no facility at the damsite for draining the lake if the need arises. Water level is maintained by rainfall, runoff, evaporation, and capacity of the uncontrolled spillway.

4.2 Maintenance of Dam

The dam is maintained by the manager of Property Owners Corporation, with corrective measures being performed as they are needed. Items that were noticed which require maintenance include clearing the downstream slope of all trees, and clearing of small trees and brush from the the spillway channel. No maintenance or water level records are kept.

4.3 Maintenance of Operating Facilities

As stated in Paragraph 4.1, there are no facilities or equipment at Cedar Hill Lake No. 1. The water level is controlled only by rainfall, runoff, evaporation, and capacity of the uncontrolled spillway.

4.4 Description of Any Warning System in Effect

The inspection team is not aware of any existing warning system in effect.

4.5 Evaluation

With the exception of those items mentioned in Paragraph 4.2, the operation and maintenance appears tc be adequate. The items listed as needing correction should be repaired within a reasonable period of time.

SECTION 5: HYDRAULIC/HYDROLOGIC

5.1 Evaluation of Features

a. Design

No design data is available.

Cedar Hill Lake No. 1 Dam has a watershed of approximately 314 acres. Land gradients in the watershed average roughly 17 percent. The lake lies on an unnamed tributary of the Big River.

Elevations within the watershed range from approximately 500 feet above MSL at the damsite to over 745 feet above MSL in the upper portion of the watershed.

The watershed is approximately 90 percent covered with forest, with the remainder being covered by grass and brush. A drainage map showing the watershed area is included in Appendix B.

Evaluation of the hydraulic and hydrologic features of Cedar Hill Lake No. 1 Dam was based on criteria set forth in the Corps of Engineers' Recommended Guidelines for Safety Inspection of Dams, and additional guidance provided by the St. Louis District of the Corps of Engineers. The Probable Maximum Flood (PMF) was calculated from the Probable Maximum Preciptation (PMP) using the methods outlined in the U.S. Weather Bureau Publication, Hydrometerological Report No. 33. The probable maximum storm duration was set at 24 hours, and storm rainfall distribution was based on criteria given in

EM 1110-2-1411 (Standard Project Storm). The SCS triangular hydrograph, transformed to a curvilinear hydrograph, was adopted for developing the unit hydrograph. The derived unit hydrograph is presented in Appendix B.

Initial and infiltration loss rates were applied to the PMP to obtain rainfall excesses. The rainfall excesses were then applied to the unit hydrograph to obtain the PMF hydrograph, utilizing the Corps of Engineers computer program HEC-1 (Dam Safety Version), which was prepared specifically for dam safety analysis. The computed peak discharge of the PMF and one-half of the PMF are 6,670 cfs and 3,335 cfs, respectively.

Both the PMF and one-half of the PMF inflow hydrographs were routed through the reservoir by the Modified Puls Method, also utilizing the HEC-1 (Dam Safety Version) computer program. The peak outflow discharges for the PMF and one-half of the PMF are 5,843 cfs and 2,594 cfs, respectively. Both the PMF and one-half of the PMF, when routed through the reservoir, resulted in overtopping of the dam.

The stage-outflow relation for the spillways were prepared from field notes and sketches. The reservoir stage-capacity data were based on the U.S.G.S. quadrangle topographic maps in combination with data given in the National Dam Safety Inventory Table. Reservoir storage capacity included surcharge levels exceeding the top of the dam, and the spillway rating curve assumed that the dam remains intact during routing. The spillway rating curves and the reservoir capacity curve are also presented in Appendix B.

From the standpoint of dam safety, the hydrologic design of a dam aims at avoiding overtopping. Overtopping is especially dangerous for an earth dam because the downrush of water over the crest will erode the dam face and, if continued long enough, will breach the dam embankment and release all the stored waters suddenly into the downstream floodplain. The safe hydrologic design of a dam calls for a spillway discharge capability in combination with an embankment crest height that can handle a very large and exceedingly rare flood without overtopping.

The Corps of Engineers designs its dams to safely pass the Probable Maximum Flood that is estimated could be generated from the upstream watershed. This is the generally accepted criterion for major dams throughout the world, and is the standard for dam safety where overtopping would pose any threat to human life.

b. Experience Data

No records of reservoir stage or spillway discharge are maintained for this site. However, according to the local residents, the maximum reservoir level was never higher than the crest of the embankment.

c. Visual Observations

The rock spillway and falls, and the exit channel are well defined and were in good condition. However, the abundance of vegetation in the spillway area would adversely affect the hydraulic efficiency of the structure.

There are no drawdown facilities to evacuate the reservoir.

d. Overtopping Potential

As indicated in Section 5.1-a., both the Probable Maximum Flood and one-half of the Probable Maximum Flood, when routed through the reservoir, resulted in overtopping of the dam. The PMF and one-half of the PMF overtopped the dam crest by 1.73 feet and 0.79 feet, respectively. The total duration of embankment overflow is 3.42 hours during the PMF, and 0.67 hours during one-half of the PMF. The spillway of the Cedar Hill Lake No. 1 Dam is capable of passing a flood equal to approximately 28 percent of the PMF just before overtopping of the dam. The 28 percent PMF has a frequency occurrence less than a 100-year frequency flood. Since the PMF is the minimum Spillway Design Flood (SDF) for Cedar Hill Lake No. 1 Dam, according to the Recommended Guidelines for Safety Inspection of Dams by the Corps, the spillway capacity of the dam is considered "Inadequate".

The effect from rupture of the dam could extend approximately two miles downstream of the dam. Within this area are six houses, two improved road crossings, and State Highway 30 crossing.

SECTION 6: STRUCTURAL STABILITY

6.1 Evaluation of Structural Stability

a. Visual Observations

The seepage occurring on the downstream embankment slope indicates a potential hazard to the structural stability of the embankment. The location and extent of the seepage area demonstrates a condition which should be analyzed in further detail.

The sloughing on the upstream slope of the embankment has not progressed to a serious extent at this time. The condition should be monitored, but no remedial measures are felt to be necessary at this time. Continual sloughing of the embankment materials will necessitate remedial measures at some future date.

The heavy vegetative growth, including large trees, on the downstream embankment slope should be cleared as soon as possible. The growth prevents proper inspection of the embankment in addition to providing a hazard to the embankment.

With the exception of an abundance of vegetation in the spillway, the spillway and the rock at the exit channel are in good condition.

b. Design and Construction Data

No design or construction data relating to the structural stability of the dam or appurtenant structures were found.

c. Operating Records

No operating records are available relating to the stability of the dam or appurtenant structures. Water levels have not been recorded, however, the reservoir was 1.5 feet below the spillway crest on the day of inspection, and is assumed to be close to full at all times. No operating facilities exist at the damsite.

d. Post Construction Changes

No post construction changes are known which will affect the structural stability of the dam.

e. Seismic Stability

In general, projects located in Seismic Zones 0, 1 and 2 can be assumed to present no hazard from earthquake, provided the static stability conditions are satisfactory and conventional safety margins exist. Cedar Hill Lake No. 1 Dam is located in Seismic Zone 1. A detailed seismic analysis is not felt to be necessary for this embankment.

SECTION 7: ASSESSMENT/REMEDIAL MEASURES

7.1 Dam Assessment

The assessment of the general condition of the dam is based upon available data and visual inspections. Detailed investigations, testing, and detailed computational evaluations are beyond the scope of a Phase I investigation; however, the investigation is intended to identify any need for such studies.

It should be realized that the reported condition of the dam is based on observations of field conditions at the time of inspection along with data available to the inspection team.

It is also important to note that the condition of a dam depends on numerous and constantly changing internal and external conditions, and is evolutionary in nature. It would be incorrect to assume that the present condition of the dam will continue to represent the condition of the dam at some point in the future. Only through continued care and inspection can there be any chance that an unsafe condition could be detected.

a. Safety

The spillway capacity of Cedar Hill Lake No. 1 Dam was found to be inadequate. The spillway is capable of passing a flood equal to 28 percent of the PMF without overtopping.

The seepage occurring on the downstream embankment slope should be investigated to determine its effect on the stability of the embankment. Seepage and stability analyses should be performed on this section in particular.

The heavy brush and tree growth on the embankment slope pose a potential hazard to the dam. The extensive tree growth is considered unsatisfactory in terms of dam safety for several reasons: First, trees toppled by wind expose holes that invite rapid erosion, and second, decay of large existing root systems could form channels for eventual piping. Rodent activity also should be eliminated on the embankment.

The sloughing of embankment materials on the upstream slope is not considered to be a serious problem at this time. However, the condition should be watched and repaired at some future date.

The vegetative growth in the spillway channel which inhibits the hydraulic efficiency of the structure should be cleared, and further growth prevented.

b. Adequacy of Information

Information concerning the dam and appurtenant structures in not available. It is recommended that the following programs be initiated to help alleviate this problem:

1. Periodic inspection of the dam by a professional engineer.

2. Set up a maintenance schedule and log all visits to the dam for operation, repairs and maintenance.

3. The dam should be surveyed and an as-built set of plans and drawings should be completed.

4. Perform seepage and stability analyses comparable to the requirements of the "Recommended Guidelines for Safety Inspection of Dams".

c. Urgency

The remedial measures recommended in Paragraph 7.2 should be accomplished in the near future.

d. Necessity for Phase II Inspection

Based on results of the Phase I inspection, and if the remedial measures recommended in Paragraph 7.2 are undertaken as soon as possible, a Phase II inspection is not felt to be necessary.

7.2 Remedial Measures

a. Alternatives

Alternatives for increasing the spillway capacity include:

1. Widening the spillway by excavating into the right abutment.

2. Lowering the crest elevation of the spillway.

3. Raising the elevation of the embankment.

4. Combination of the above.

b. Seepage and stability analyses should be performed by a professional engineer experienced in the design and construction of dams. This study should concentrate on the area exhibiting seepage on the downstream slope.

d. Repair the erosion and sloughing on the upstream embankment slope as is becomes necessary.

e. O & M Maintenance Procedures

The owner should initiate the following programs:

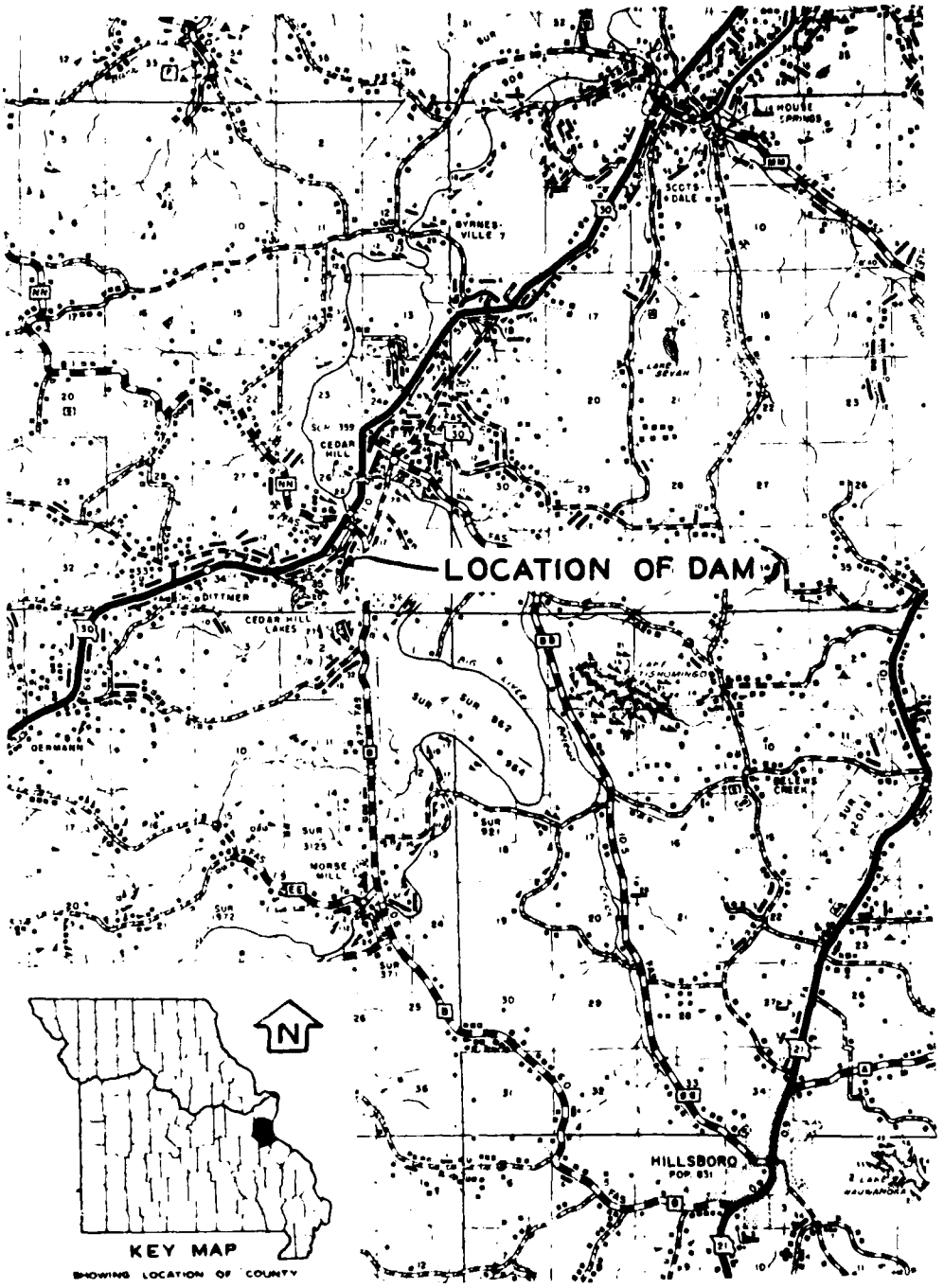
1. Periodic inspection of the dam by a professional engineer.

2. Set up a maintenance schedule and log all visits to the dam for operation, repairs and maintenance.

3. Clear the vegetative growth from the spillway channel. Keep the fence across the spillway free of debris.

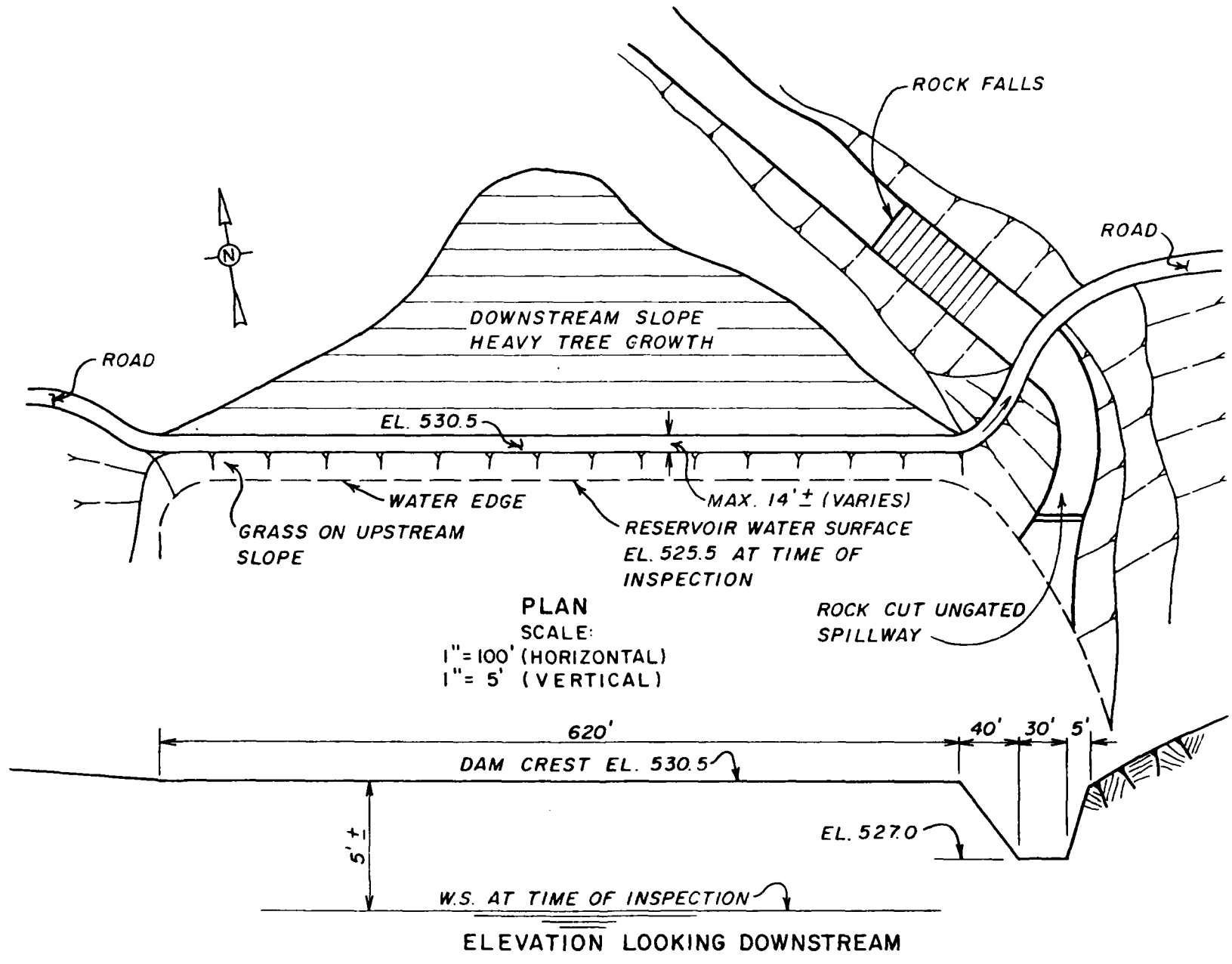
4. The dam should be surveyed and an as-built set of plans and drawings should be completed.

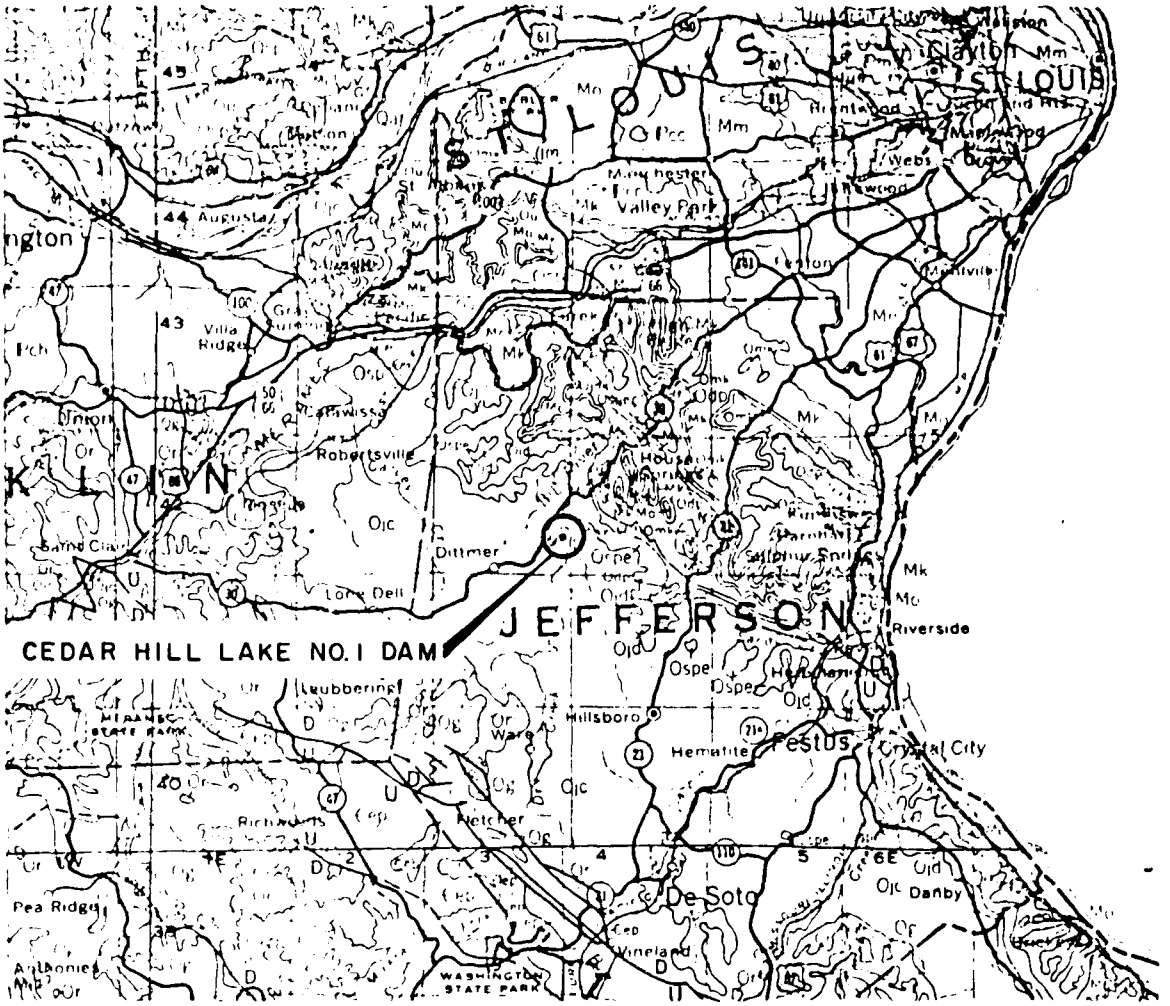
PLATES



LOCATION MAP
CEDAR HILL LAKE NO1 DAM
JEFFERSON COUNTY, MISSOURI

CEDAR HILL #1 DAM
RELATIVE ELEVATIONS





General Geologic Map

Explanation

Mississippian System

M_o - cherty and crinoidal limestone, with some shale.
M_k - intercalated limestones and shales.

Ordovician System

O_{mk} - shale and limestone.
O_{dp} - shale with thin fossiliferous limestone beds and dense limestone.
O_{jd} - dolomite with interbedded limestone, shale, and black limestone.
O_{spe} - massive, cross-bedded sandstone; and dolomite, lithographic limestone with interbedded sandstone.
O_{jc} - silty and cherty dolomite with oolitic chert.
O_r - sandstone, chert, and interbedded dolomite.
O_g - cherty dolomite with a basal sandstone.

Reference: Geologic Map of Missouri, 1961, Division of Geological Survey and Water Resources, State of Missouri.

APPENDIX A

PHOTOGRAPHS TAKEN DURING INSPECTION

CEDAR HILL LAKE DAM NO. 1

Photo 1 - View of upstream slope of embankment taken from left abutment. Spillway is located at far right side of dam.

Photo 2 - View of typical section of downstream embankment slope.

Photo 3 - Close-up of seepage area on downstream embankment slope at right side of dam.

Photo 4 - Close-up of moisture indicating seepage near location of Photo 3.

Photo 5 - Picture of approach channel for spillway at right abutment of dam.

Photo 6 - Picture of spillway channel with concrete weir and fence taken from downstream looking upstream.

Photo 7 - Picture of spillway channel taken from road looking upstream.

Photo 8 - Picture of spillway discharge channel bedrock taken just downstream of road.

Photo 1 - View of upstream slope of embankment taken from left abutment. Spillway is located at far right side of dam.

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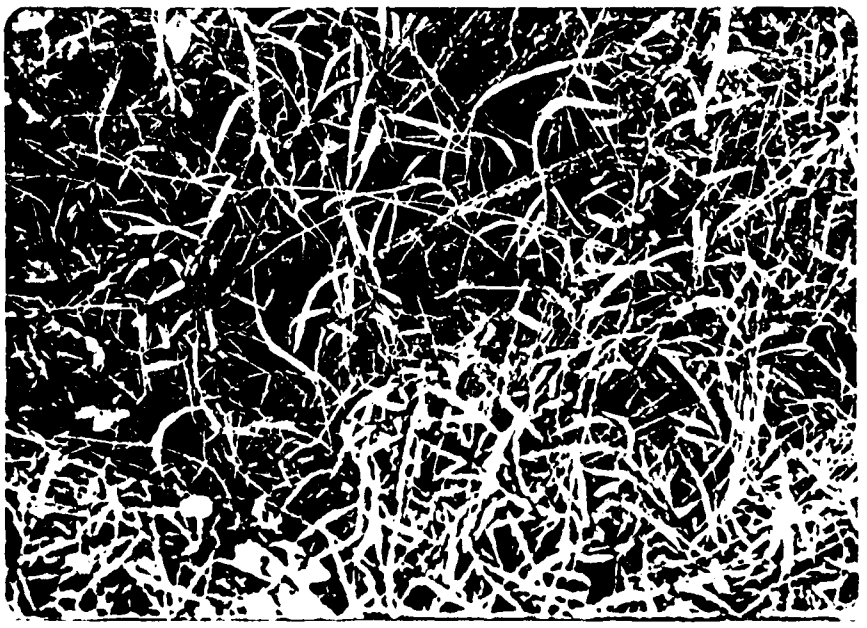

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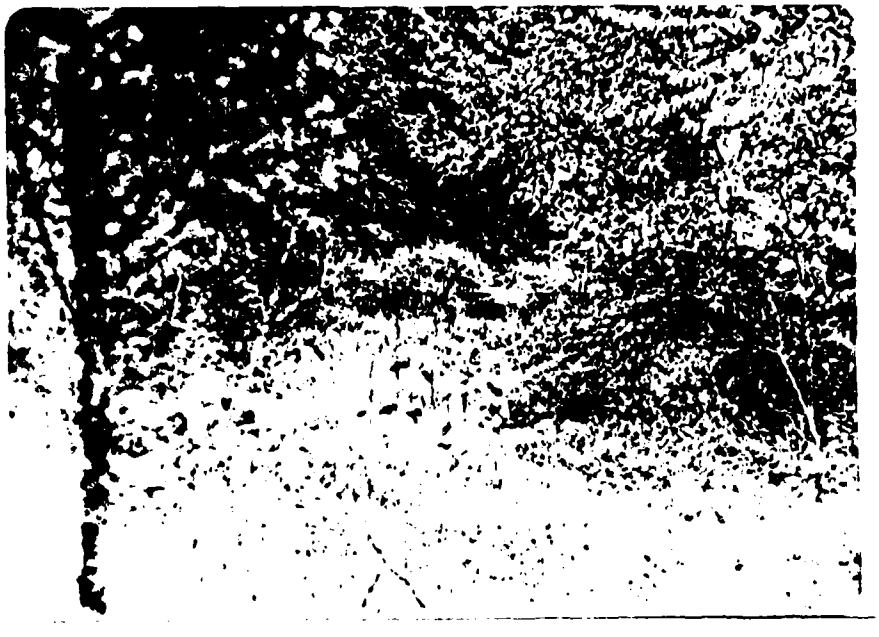


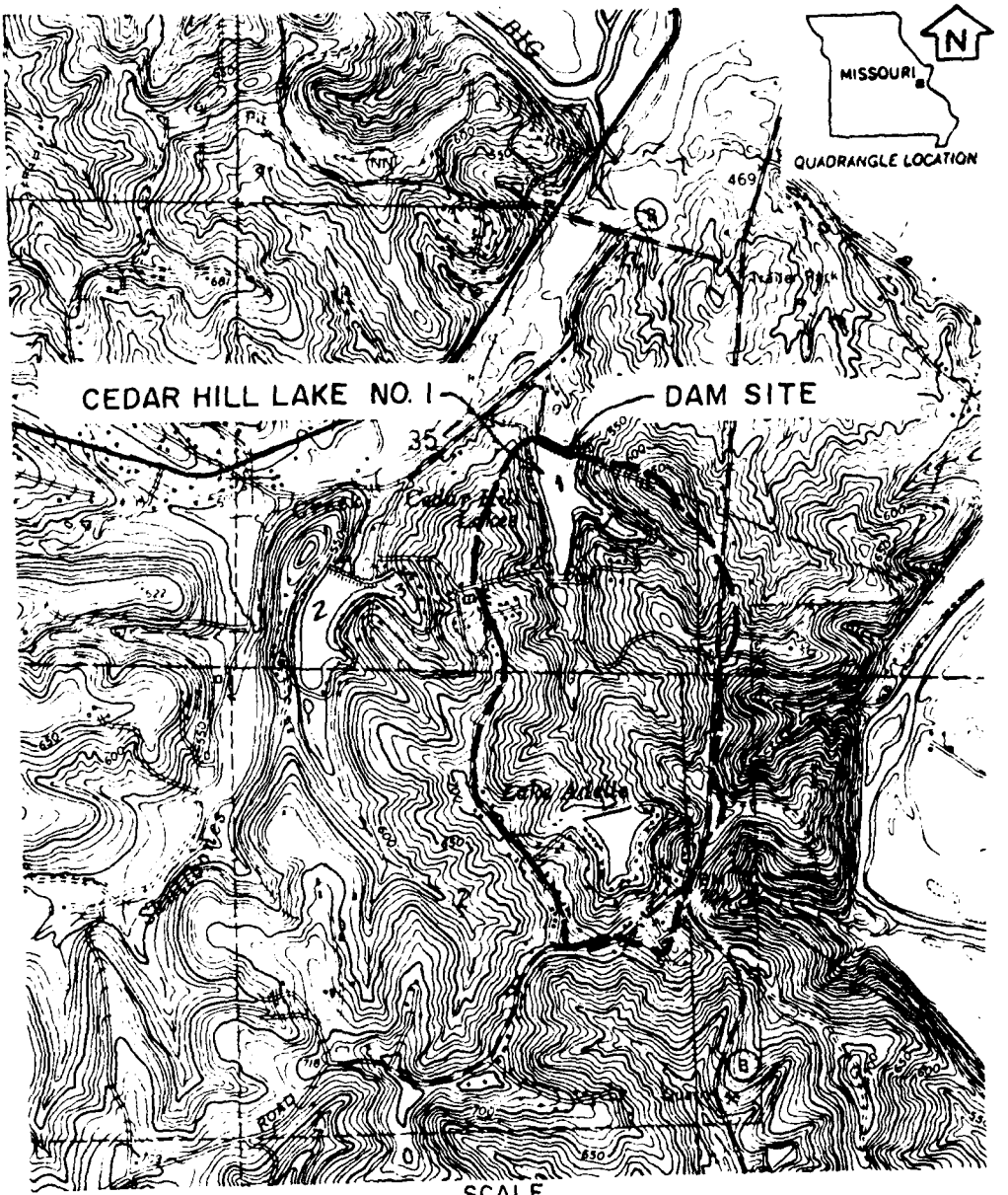
Photo 6 - Picture of spillway channel with concrete weir and fence taken from downstream looking upstream.

Photo 7 - Picture of spillway channel taken from road looking upstream.

Photo 8 - Picture of spillway discharge channel bedrock taken just downstream of road.

APPENDIX B

HYDROLOGIC COMPUTATIONS



CONTOUR INTERVAL 10 FEET
NATIONAL GEODETIC VERTICAL DATUM OF 1929

DRAINAGE BOUNDARY — — — — —

CEDAR HILL LAKE NO. 1 DAM
DRAINAGE AREA

ECI-4 ENGINEERING CONSULTANTS, INC.

DAM SAFETY INSPECTION – MISSOURI
CEDAR HILL LAKE NUMBER 1 DAM
RESERVOIR AREA CAPACITY DATA

SHEET NO. 1 OF 2
JOB NO. 1223-001-1
BY KLB DATE 11-17-78

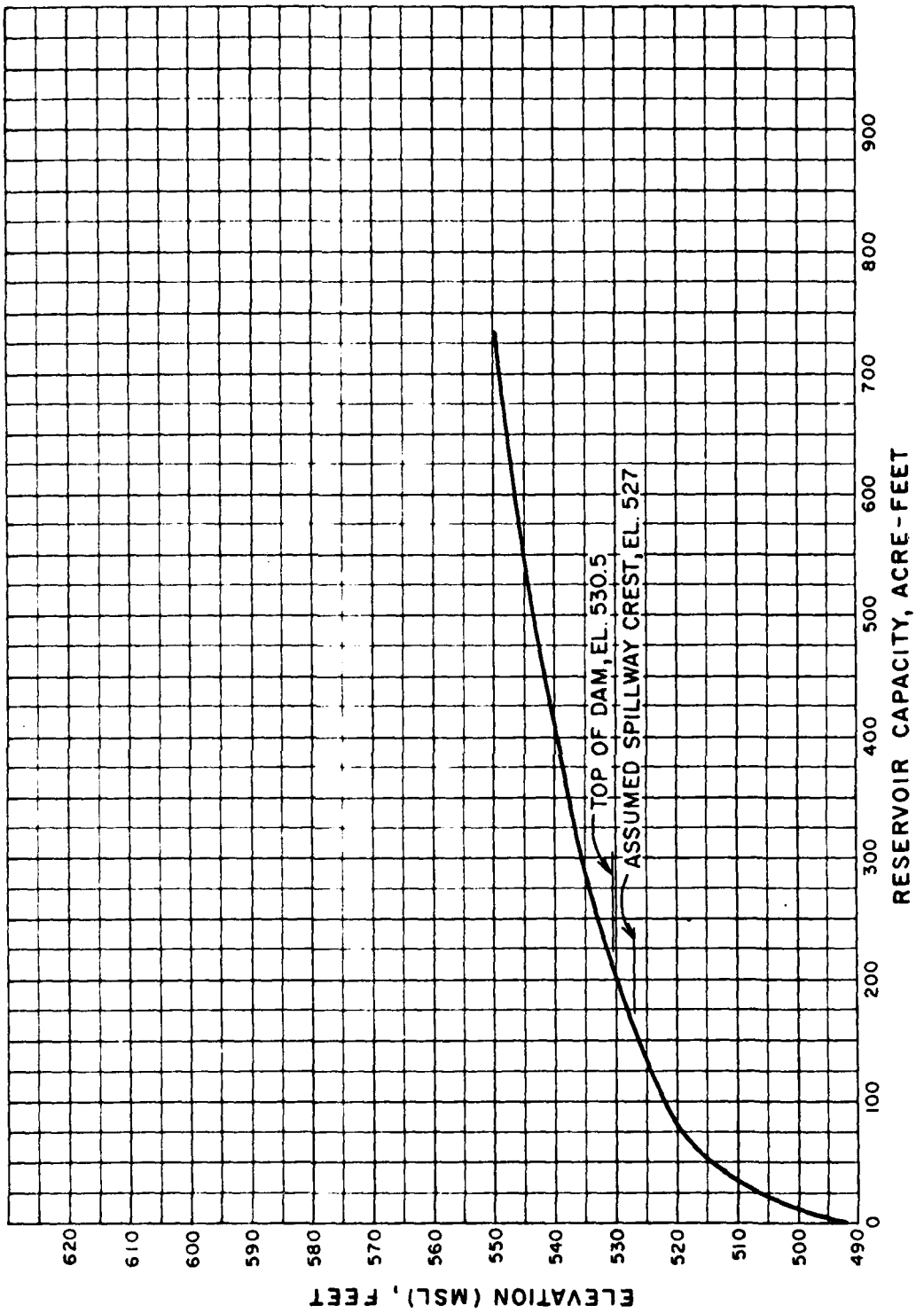
LM

CEDAR HILL LAKE NUMBER 1 DAM

RESERVOIR AREA CAPACITY DATA.

ELEV. (FT.)	SURFACE AREA (ACRES)	INCREMENTAL VOLUME (AC-FT)	TOTAL VOLUME (AC-FT)	REMARKS
492	0	–	0	
520	8.6*	80	80	
527	13*	76	156	ASSUMED SPILLWAY CREST ELEV.
530	16	44	200	AREA MEASURED ON U.S G.S. MAP
530.5	16.4*	8	208	TOP OF DAM
540	26	201	409	AREA MEASURED ON U.S.G.S. MAP
550	37	315	724	AREA MEASURED ON U.S G.S. MAP

* [illegible] ONLY



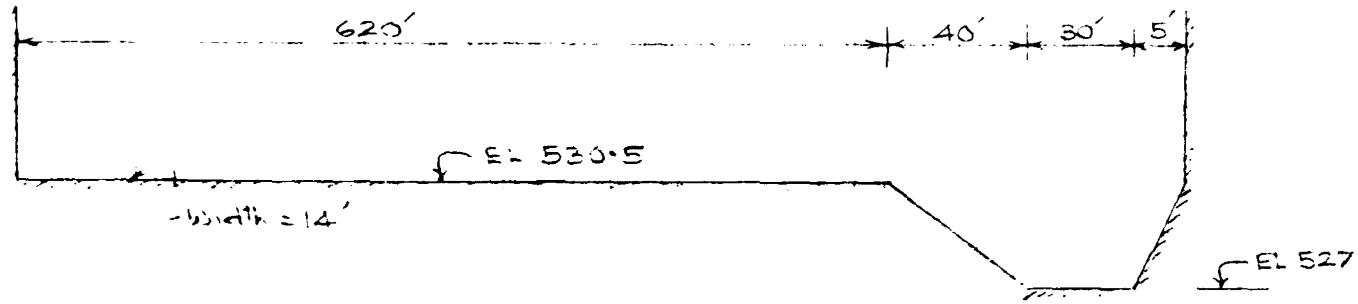
CEDAR HILL LAKE #1 DAM
RESERVOIR CAPACITY CURVE

ECI-4 ENGINEERING CONSULTANTS, INC.

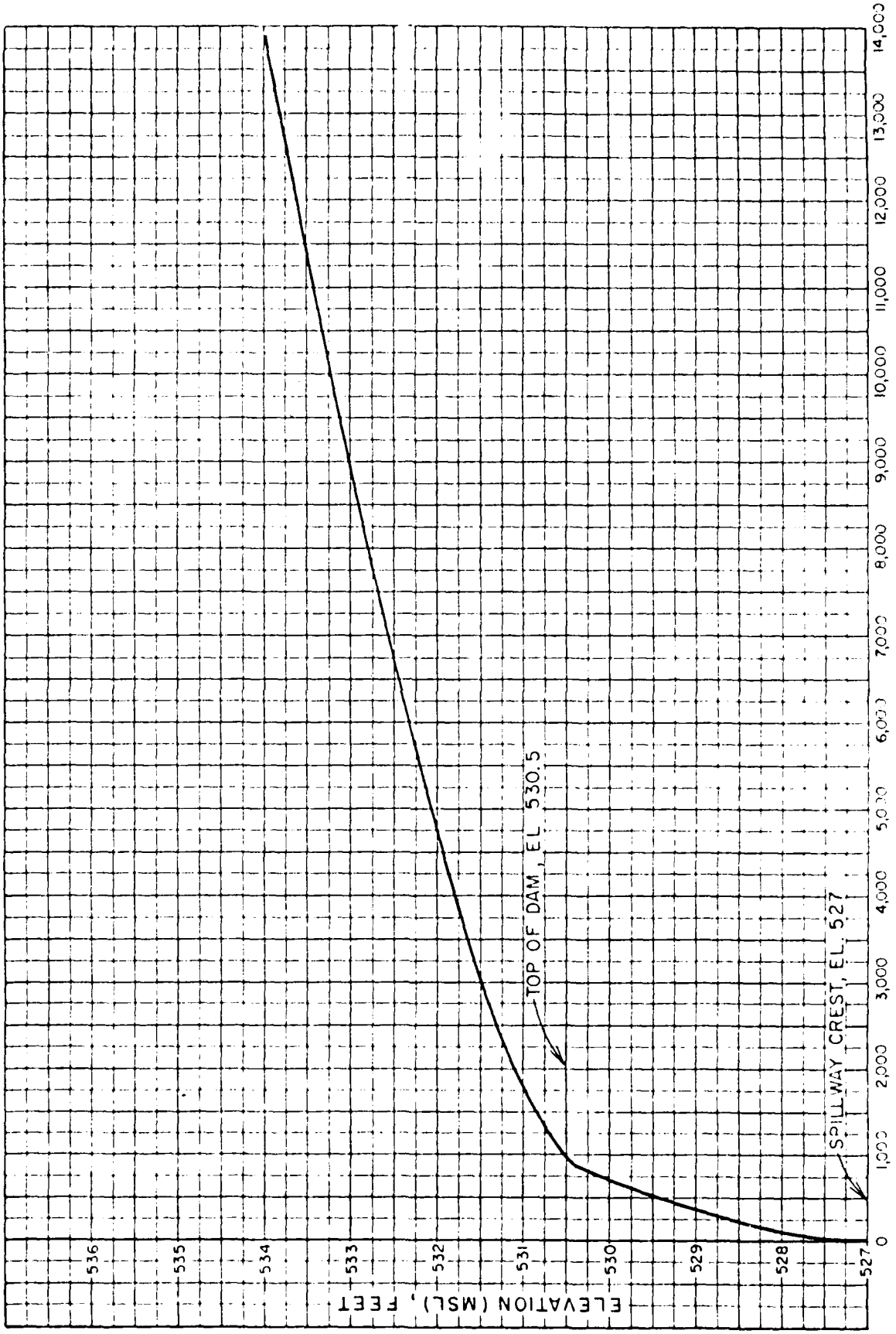
DAM SAFETY INSPECTION, MISSOURI — SHEET NO. 1 OF 2

C... HILL LAKE NUMBER 1 DAM — JOB NO. 1223-001

– SPILLWAY & OVERTOP DISCHARGE CAPACITY — BY MAE DATE 11/15/78



y_{c1}	T_{c1}	A_{c1}	$V_{c1} = 5.67\sqrt{A_{c1}/T_{c1}}$	$Q_1 = A_{c1}V_{c1}$	Upstream Water Surface Elev = $527 + y_{c1} + \frac{V_{c1}^2}{2g}$	H_2	C_2	L_2	Q_2	$Q_T = Q_1 + Q_2$
1	42.86	36.43	5.23	191	528.42					191
2	55.72	85.72	7.03	603	529.77					603
2.5	62.15	115.19	7.72	889	530.43					889
3	68.58	147.87	8.33	1232	531.08	0.58	2.70	620	739	1,971
3.5	75.00	183.75	8.97	1630	531.72	1.22	2.64	620	2206	3836
4.25	75.00	240.00	10.14	2434	532.85	2.35	2.63	620	5,861	8,295
5	75.00	296.25	11.27	3338	533.97	3.47	2.63	620	10,540	13,878



CEDAR HILL LAKE #1 DAM

SPILLWAY & OVERTOP RATING CURVE

ECI-4 ENGINEERING CONSULTANTS, INC.

DAM SAFETY INSPECTION - MISSOURI — SHEET NO. 1 OF 3
CEDAR HILL NUMBER 1 DAM — JOB NO. 1223-001-1
UNIT HYDROGRAPH PARAMETERS — BY KLB DATE 11-16-78

1. DRAINAGE AREA = 314 AC = 0.49 SQ. MI.

2. LENGTH OF STREAM, L = (1.7" × 2000'/5280) = 0.64 MI.

3 DIFFERENCE IN ELEVATION, ΔH

$\Delta H = 745 - 525 = 220$

4. TIME OF CONCENTRATION, T_c

$$T_c = \left(\frac{11.9 \times L^3}{\Delta H}\right)^{0.385}$$

$$T_c = \left(\frac{11.9 \times 0.64^3}{220}\right)^{0.385}$$

$T_c = \underline{0.19 \text{ HR.}}$

5. LAG TIME, $L_t = 0.6 \times T_c$

$L_t = 0.6 \times 0.19 = 0.11$ HR.

6. RAINFALL UNIT DURATION, D:

$D \leq \frac{L_t}{4} = \frac{0.11}{4} = 0.03$ HR

USE $D = 5$ MIN $= 0.083$ HR

MINIMUM DURATION CRITERIA.

7. TIME TO PEAK, T_p

$T_p = \frac{D}{2} + 0.6 \times T_c = \frac{0.083}{2} + 0.6 \times 0.19$

$T_p = \underline{0.16 \text{ HR}}$

8 $q_p = \frac{484 \times A}{T_p} = \frac{484 \times 0.49}{0.16} = \underline{1482}$ CFS

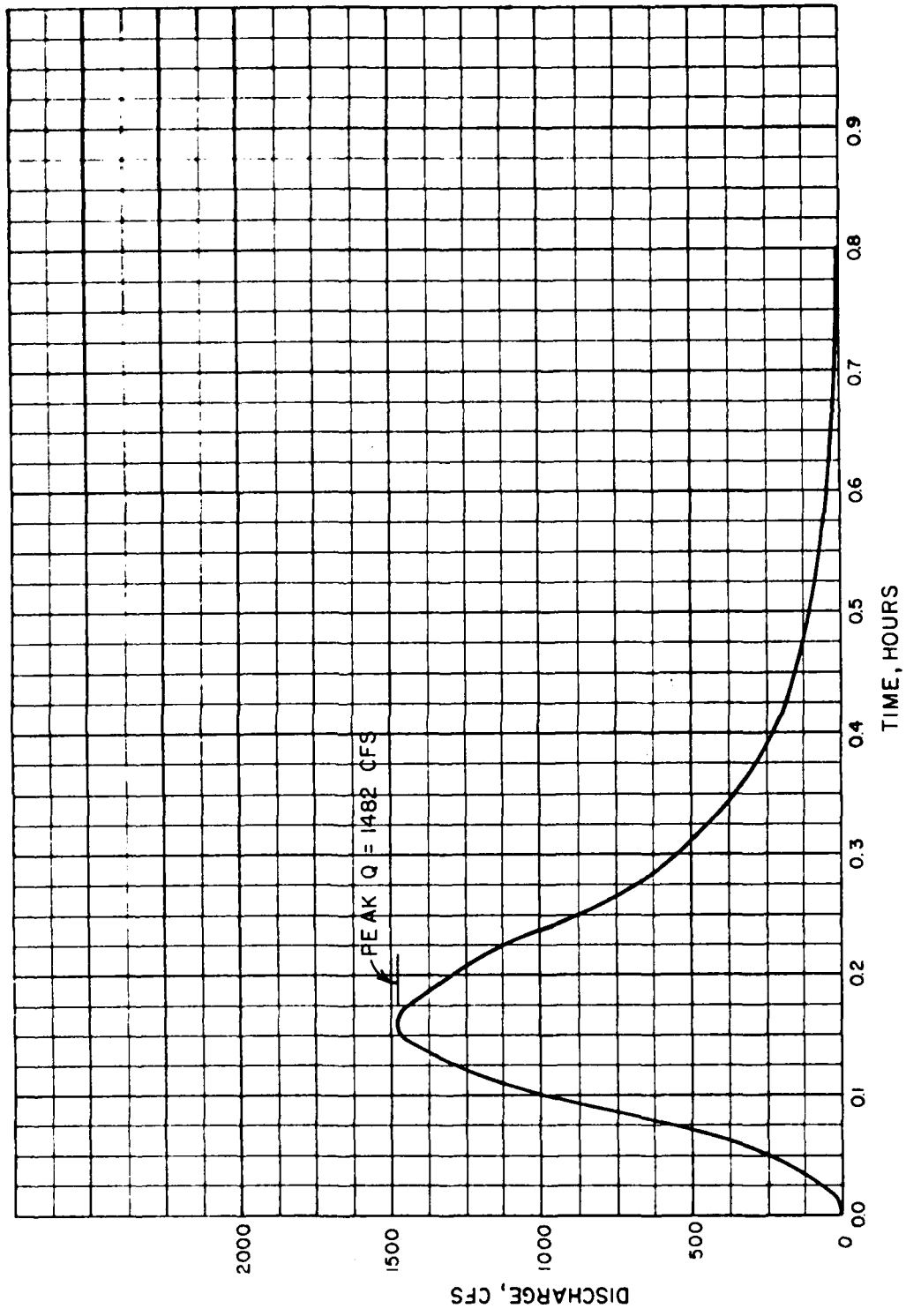
ENGINEERING CONSULTANTS, INC.

DAM SAFETY INSPECTION - MISSOURI
CEDAR HILL NUMBER 1 DAM
UNIT HYDROGRAPH DERIVATION

SHEET NO. 2 OF 3
JOB NO. 1223-001-1
BY KLB DATE 11-16-78

4) CURVILINEAR UNIT HYDROGRAPH

Time T/Tp	Discharge Ratio Q/Qp	Unit Hydrograph	
		Time, T (HR)	Discharge (CFS)
0.000	0.000	0.000	0.000
0.1	0.015	0.02	22.23
0.2	0.075	0.03	111.15
0.3	0.16	0.05	237.12
0.4	0.28	0.06	414.96
0.5	0.45	0.08	666.90
0.6	0.60	0.10	889.20
0.7	0.77	0.11	1141.14
0.8	0.89	0.13	1318.98
0.9	0.97	0.14	1437.54
1.0	1.00	0.16	1482.00
1.1	0.98	0.18	1452.36
1.2	0.92	0.19	1363.44
1.3	0.84	0.21	1244.88
1.4	0.75	0.22	1111.50
1.5	0.66	0.24	978.12
1.6	0.56	0.26	829.92
1.8	0.42	0.29	622.44
2.0	0.32	0.32	474.24
2.2	0.24	0.35	355.68
2.4	0.18	0.38	266.76
2.6	0.13	0.42	192.66
2.8	0.098	0.45	145.24
3.0	0.075	0.48	111.15
3.5	0.036	0.56	53.35
4.0	0.018	0.64	26.68
4.5	0.009	0.72	13.34
5.0	0.004	0.80	5.93



CEDAR HILL LAKE # 1 DAM
5 MINUTE UNIT HYDROGRAPH

DETERMINATION OF PMS

1. Determine drainage area of the basin

   D.A. = 314 acres = 0.49 sq. mi.

2. Determine PMP Index rainfall:

   Location of centroid of basin:

   Long. 90.64°; Lat.: 38.33°

   → PMP for 200 sq. mi. & 24 hrs duration

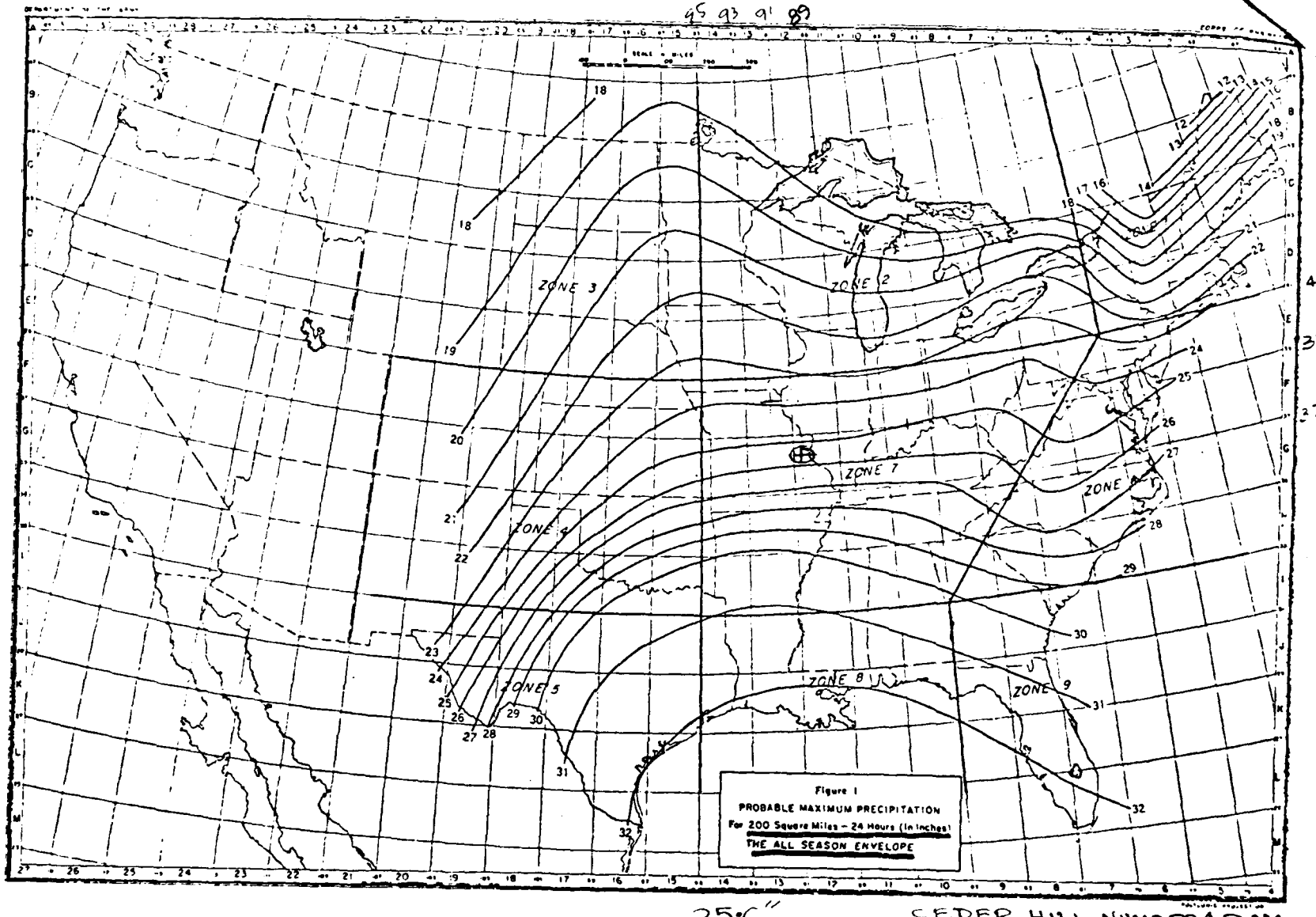
   = 25.6" (from Fig 1, HMR NO 33)

3. Determine basin rainfall interms of percentage of PMP Index rainfall for various durations:

   Location: Long. 90.64°; Lat. 38.33°

   ⇒ Zone 7

Duration (Hrs.)	Percent of Index rainfall (%)	Total rainfall (Inches)	Rainfall increments (Inches)	Duration of increment (Hrs.)
6	100	25.6	25.6	6
12	120	30.7	5.1	6
24	130	33.3	2.6	12



95 93 91 89

41

39

37

20

25·6"

CEDER HILL NUMBER 1 DAM
DETERMINATION OF PMP

ENGINEERING CONSULTANTS, INC.

DAM SAFETY INSPECTION - MISSOURI
CEDAR HILL LAKE NUMBER 1 DAM
100 YR FLOOD BY REGRESSION EQUATION

SHEET NO. 1 OF 1
JOB NO. 1233-001-1
BY KLB DATE 11-20-78

CEDAR HILL #1 DAM

100-YEAR FLOOD BY REGRESSION EQUATION

REGRESSION EQUATION FOR 100 YEAR FLOOD FOR MISSOURI:

$$Q_{100} = 85.1\ A^{0.934\ A^{-0.02}}\ S^{0.576}$$

WHERE

A = DRAINAGE AREA IN SQ. MI.

S = MAIN CHANNEL SLOPE, FT./MI
(AVG SLOPE BETWEEN 0.1 L AND 0.85 L,
L, BEING LENGTH OF STREAM).

FOR CEDAR HILL #1 DAM:

$A = 0.49$ SQ. MI.

$$S = \frac{700 - 530}{0.75 \times 0.64} = \frac{170}{0.48} = 354.17 \text{ FT/MI.}$$

$$Q_{100} = 85.1\ (0.49)^{0.934(0.49)^{-0.02}}\ 354.17^{0.576}$$

$$= \underline{1273 \text{ CFS}}$$

HEC1DB INPUT DATA

```
FLOOD HYDROGRAPH PACKAGE (HEC-1)
DAM SAFETY VERSION  JULY 1978
 LAST MODIFICATION  01 AUG 78

     1     A1   DAM SAFETY INSPECTION - MISSOURI
     2     A2   CEDAR HILL LAKE NUMBER 1 DAM
     3     A3   PMF AND 50 PERCENT PMF DETERMINATION AND ROUTING
     4     R    100       0       0       0       0       0       0       0       0
     5     R1
     6     J    1       2       1
     7     J1   1.0     0.5
     8     K    0       16
     9     K1   INPUT PMP INDEX PRECIPITATION AND RATIOS, INPUT SCS UNIT HYDROGRAPH
    10     M    1       41      0.49            0.49    1.0
    11     P            25.6    100     120     130
    12     Y                                                    1.00    0.08
    13     U    13
    14     U1   0.0     713     1482    868     416     198     97      40      20      4
    15     U1   4       1       0.0
    16     T            0.      1
    17     K    1       14                      2               1
    18     K1   ROUTE HYDROGRAPH THROUGH CEDAR HILL NUMBER 1 DAM
    19     Y                                   1       1
    20     Y1   1                                               -527.   -1
    21     Y4   527     528.42  529.77  530.43  530.50  531.08  531.72  532.86  533.97
    22     Y5   0.0     191     603     889     935     1971    3836    8295    13874
    23     X8   0.      80      156     200     208     409     724
    24     CF   492     520     527     530     530.5   540     550
    25     X8   527
    26     CD   530.5
    27     R    99
```

PRINTOUT OF SEQUENCE OF STREAM NETWORK CALCULATIONS

RUNOFF HYDROGRAPH AT
ROUTE HYDROGRAPH TO
END OF NETWORK

INFLOW PMF AND ONE-HALF PMF HYDROGRAPHS

```
   FEDDO-HYDROGRAPH PACKAGE (HPE-1)
DAM SAFETY VERSION   JULY 1978
   LAST MODIFICATION  21 AUG 78

 RUN DATE= 78/11/28.
      TIME= 10.31.09.
```

DAM SAFETY INSPECTION - MISSOURI
CEDAR MILL LAKE NUMBER 1 DAM
PMP AND 50 PERCENT PMP DETERMINATION AND ROUTING

JOB SPECIFICATION

NO	NHR	NMIN	IDAY	IHR	IMIN	METRC	IPLT	IPRT	NSTAN
100	0	5	0	0	0	0	0	0	0

IOPER	NRT	LROPT	TRACE
5	0	0	0

MULTI-PLAN ANALYSES TO BE PERFORMED
NPLANS= 1 NRTIOS= 2 LRTIOS= 1

RTIOS= 1.00 .50

SUB-AREA RUNOFF COMPUTATION

INPUT PMP UNDER PRECIPITATION AND RATIOS, INPUT SCS UNI

ISTAQ	ICOMP	IECON	ITAPE	JPLT	JPRT	INAME	ISTAGE	IAUTO
14	0	0	0	0	0	1	0	0

HYDROGRAPH DATA

IHOUR	TAREA	SNAP	TRSDA	TRSPC	RATIO	ISNOW	ISAME	LOCAL
.80	0.00	.00	1.00	0.000	0	0	0	

PRECIP DATA

SPFE	PMP	R6	R12	R24	R48	R72	R96
0.00	25.00	100.00	120.00	150.00	0.00	0.00	0.00

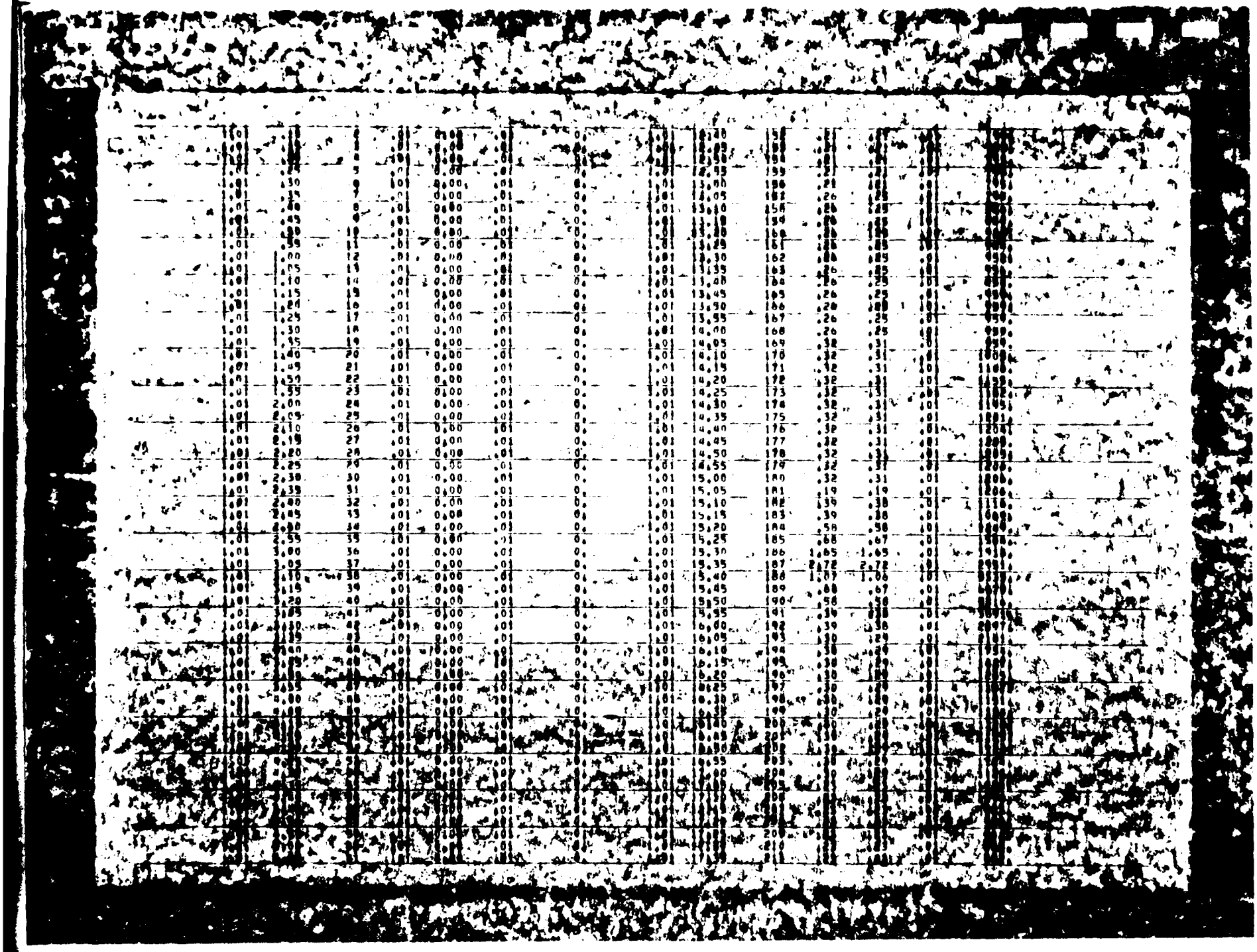
LOSS DATA

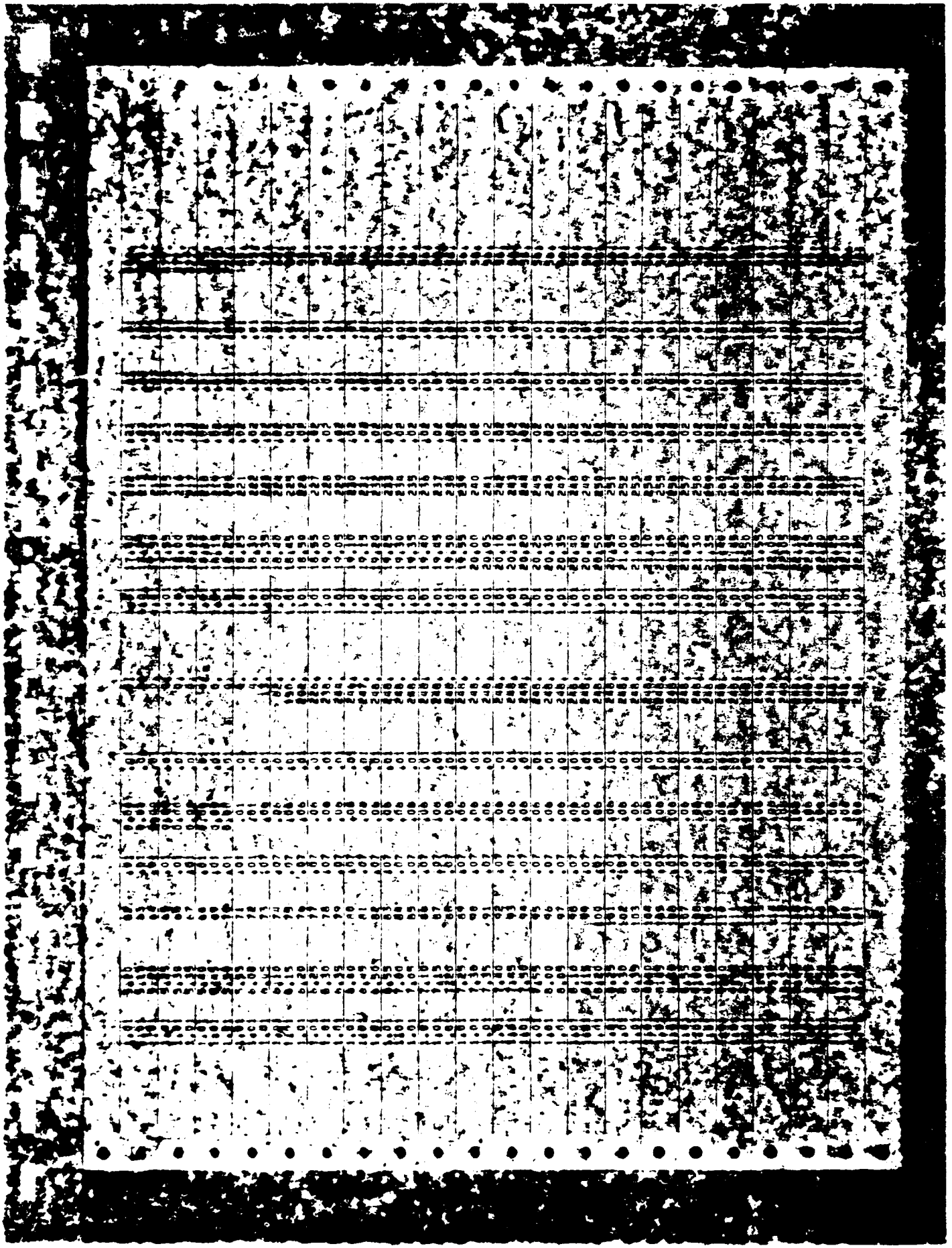
LROPT	STRKR	DLTKR	RTIOL	ERAIN	STRKS	RTIOS	STRTL	CNSTL	ALSMX	RTIMP
0	0.00	0.00	1.00	0.00	0.00	2.00	1.00	.00	0.00	0.00

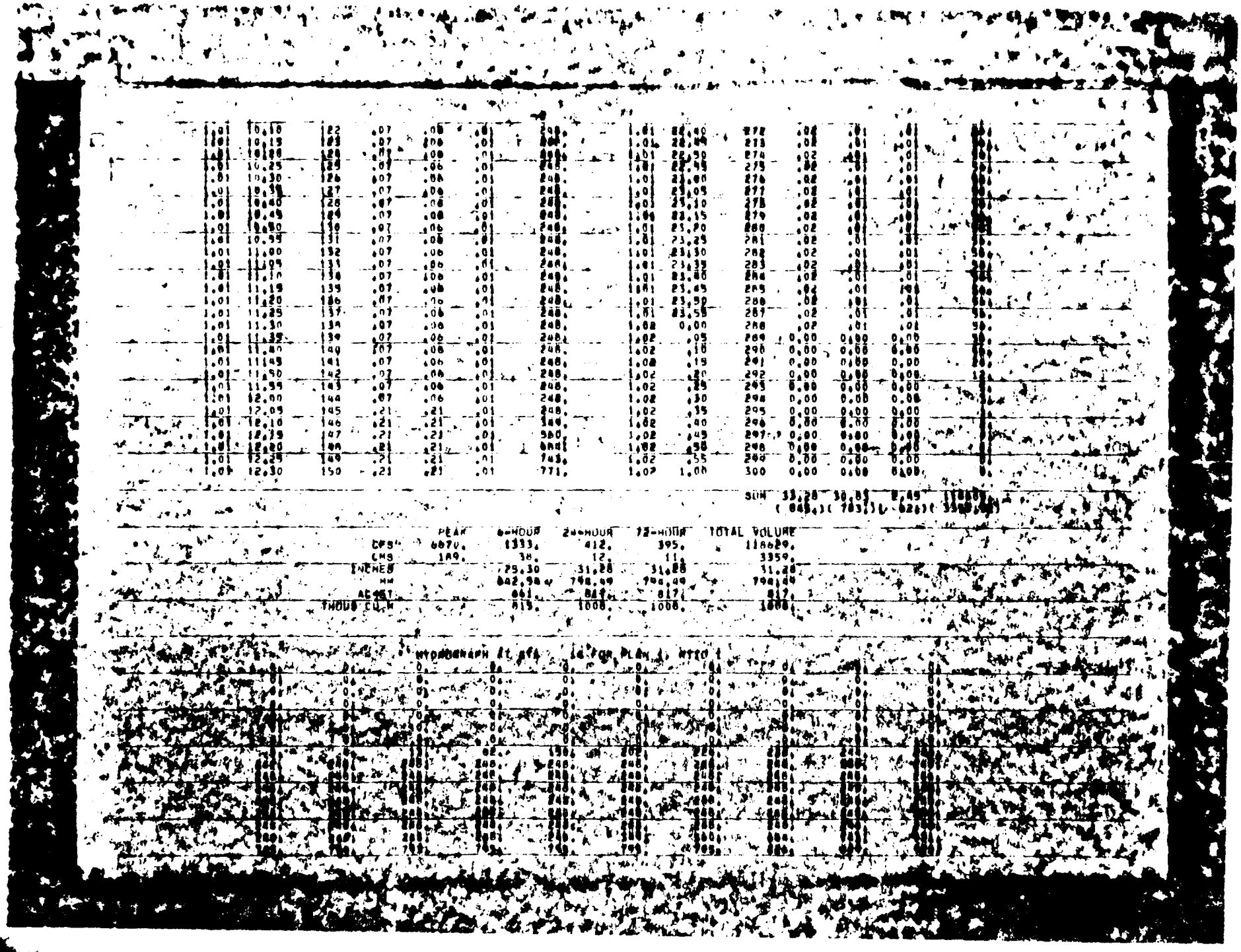
UNIT GRAPH DATA

UNIT HYDROGRAPH 101 END-OF-PERIOD ORDINATES, LAG= .00 HOURS, CP= .00 VOL= 1.00

1	2	3	4	5	6	7	8	9	10
11	12	13	14	15	16	17	18	19	20
21	22	23	24	25	26	27	28	29	30
31	32	33	34	35	36	37	38	39	40
41	42	43	44	45	46	47	48	49	50
51	52	53	54	55	56	57	58	59	60
61	62	63	64	65	66	67	68	69	70
71	72	73	74	75	76	77	78	79	80
81	82	83	84	85	86	87	88	89	90
91	92	93	94	95	96	97	98	99	100
101									







HYDROGRAPH ROUTING

ROUTE HYDROGRAPH THROUGH CEDAR HILL NUMBER 1 DAM

ISTAO	ICOMP	IECON	ITAPE	JPLT	JPRT	INAME	ISTAGE	IAUTO
14	1	0	0	2	0	1	0	0

ROUTING DATA

QLOSS	CLOSS	AVG	IRES	ISAME	IOPT	IPMP	LSTR
0.0	0.000	0.00	1	1	0	0	0

NSTPS	NSTDL	LAG	AMSKK	X	TSK	STORA	ISPRAT
1	0	0	0.000	0.000	0.000	4527.	-1

STAGE	527.0	528.4	529.8	530.4	530.5	531.1	531.7	532.9	534.0
FLOW	0.	191.	603.	889.	935.	1971.	3836.	8295.	13871.
CAPACITY=	0.	80.	156.	200.	206.	404.	724.		
ELEVATIONS	492.	520.	527.	530.	531.	540.	550.		

CREL	SPWID	COOW	EXPW	ELEVL	COOL	CAREA	EXPL
527.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

DAM DATA

TOPEL	COOD	EXPD	DAMWID
53019.	0.0	0.0	0.

STATION 14, PLAN 1, RATIO 1

END-OF-PERIOD HYDROGRAPH ORDINATES

OUTFLOW

SUMMARY OF PMF AND ONE-HALF PMF FLOOD ROUTING

AND

DAM SAFETY ANALYSIS

PEAK FLOW AND STORAGE (END OF PERIOD) SUMMARY FOR MULTIPLE PLAN-RATIO ECONOMIC COMPUTATIONS
FLOWS IN CUBIC FEET PER SECOND (CUBIC METERS PER SECOND)
AREA IN SQUARE MILES (SQUARE KILOMETERS)

OPERATION	STATION	AREA	PLAN	RATIO 1 1.00	RATIO 2 .50
HYDROGRAPH AT	10	.49 (1.27)	1	6630. (188.87)	3535. (99.48)
ROUTED TO	10	.49 (1.27)	1	5943. (169.45)	2994. (73.85)

RATIOS APPLIED TO FLOWS

Summary of Dam Safety Analysis

PLAN 1 .....

	INITIAL VALUE	SPILLWAY CREST	TOP OF DAM
ELEVATION	527.00	527.00	530.50
STORAGE	150.	150.	208.
OUTFLOW	0.	0.	915.

RATIO OF PMF	MAXIMUM RESERVOIR W.S.ELEV	MAXIMUM DEPTH OVER DAM	MAXIMUM STORAGE AC-FT	MAXIMUM OUTFLOW CFS	DURATION OVER TOP HOURS	TIME OF MAX OUTFLOW HOURS	TIME OF FAILURE HOURS
1.00	530.23	1.73	249.	5843.	3.42	15.83	0.00
.50	531.29	.79	225.	2504.	.67	15.83	0.00


DAT
ILM